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A comparative study of the procurement practices of some significant state-owned mining companies

Enkhtuvshin Lkhagvajav[1*], Ganchimeg Jamsran[1*] and Enkhbayar Jamsranjav[2*]

[1] *Graduate School of Business, Mongolian University of Science and Technology*
[2] *School of Information Technology and Electronics of National University of Mongolia*

**Corresponding author: enkhbayar.j@num.edu.mn; ORCID:0000-0003-4576-3864*

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Abstract: Mongolia's mining sector alone accounts for 25 percent of the gross domestic product. In the current conditions of globalization, the role of procurement in any country's social and economic development tends to increase more and more. Investment and procurement activities to convert the country's budget into efficient use have determined a new approach to countries' social, economic, and industrial development. Organizing government procurement effectively becomes one of the critical issues to creating an optimal economic structure, increasing the efficiency of the use of all types of resources, improving the productivity of the national economy, ensuring the sustainable social and economic development of the country, and spend the country's budget efficiently and effectively.
Mongolia has developed and approved legal acts with a particular focus on forming the legal basis of the economic system and procurement. In recent years, foreign trade turnover has steadily increased. In particular, the foreign trade deficit is decreasing every year.
The total turnover of foreign trade in 2005 was 2241.2 million US dollars, in 2010 it was 6108.6 million US dollars, in 2015 it was 8466.8 million US dollars, in 2017 it was 10536.12 million US dollars, which was increased by 27.3% or 2261.6 million US dollars from the previous period. Mineral raw materials and textiles accounted for 71.1% of total exports in 2000, while in 2005, mineral raw materials and precious metals accounted for 73.9%. In 2010, these products accounted for 87.1%, and in 2017, they increased by 2.1 points to 89.2%. In 2022, the share of treasure products in exports was 84.1%. Therefore, it is essential to conduct a comparative study and analysis of the procurement process of major mining enterprises in our country.

Key words: state mining enterprises, procurement, mathematical modeling.

1. Introduction

Since the 1990s, Mongolia has transitioned from a planned economy to a free market. Since then, significant changes have occurred in the country's society and economy. In this way, the foundations for the formation and development of an entirely new socio-economic system based on market relations were laid in Mongolia. Changes and reforms taking place rapidly in the world have affected countries' social and economic development. Along with this, the role of procurement has become increasingly important.

Procurement activities will determine a new approach to social, economic, and industrial development when the country's budget transforms into efficient consumption. The competitiveness of countries depends not on the number of people, the size of the territory, or natural resources but on the effective use of their resources. Procurement began to play a significant role in this.

According to global experience, many countries have developed procurement policies suitable for their characteristics and have achieved results. It plays a decisive role in developed

countries' social and economic development. However, for developing countries, it is one of the main ways to increase the rate of economic growth and overcome backwardness.

In our country, since 2000, the government has been paying particular attention to forming the legal basis for procurement and has developed and approved legal acts.

It is becoming essential to study the effective management of procurement activities, including the procurement activities of state mining enterprises.

2. Theoretical backgrounds

Procurement efficiency has a significant impact on a company's financial performance. Since more than 70% of the cost of manufactured products is purchased goods, materials, and technical resources, small savings obtained during the procurement process increase the enterprise's total profit and financial stability.

Harrison and Van A. Hoek believe that procurement is the most "expensive" in the group of operating expenses and has the most significant impact on the efficiency of enterprises. At the same time, the value of purchased products and inventory decreases, reducing the amount of capital associated with them. Changes in these two factors - profit growth and inventory reduction - directly affect business profitability [1].

Researcher A.G. Nikolayeva believes that an essential factor in effective procurement management is the amount of liabilities that arise when communicating with suppliers and contractors. This type of debt is an unfavorable factor for enterprises, and if it increases, it can threaten the stability of the entire business [2].

According to the researcher D. L. Volkov, it is essential to understand the business sector because the impact of working capital and its components on profitability will differ and depend on many factors [3].

Research by E. Shueng, H. Xin, M. Porporato, M. Vasab, and many other academics has shown that the financial cycle is used to evaluate the effectiveness of working capital management. Effective management of financial cycle components is vital to increase business returns [4] [5] [6].

M. Porporato and M. Vasab, analyzing the research conducted on the example of the markets of foreign countries, found that reducing the financial cycle can increase the return. In other words, the smaller the share of working capital in the income, the more efficient the organization's business is. However, numerous studies have found an inverse and direct relationship between return on assets and inventory turnover time. This is due to the additional resources available in the system. In other words, it is possible to create a necessary, safe reserve to prevent the occurrence of unforeseen situations during the supply process, thereby overcoming the situation in a short time at a low cost [7].

Researcher R. E. Boyko notes that the inverse relationship between accounts payable and return on assets is also ambiguous. In some cases, it is influenced by factors such as the company's industry, the period of the study, the company's profitability and size, and the level of market competition [8].

Researchers K. Lysons and M. Gillingham state that the company places a specific part of the material resources supplied by suppliers in the form of raw materials and semi-finished products in the warehouse. This was considered to constitute the relevant part of working capital—the "dead" time in which inventory is stockpiled increases the length of production and operational cycles. However, the payment terms of supplies affect the duration of the financial cycle [9].

In addition, the stock of raw materials in the warehouse ensures production continuity and reduces production risk. As a result, the organization and economic stability of the enterprise is ensured. On the other hand, inventory is the main component of the working capital of an enterprise. Its cost, structure, and changing trends directly affect the enterprise's financial

stability. In this regard, it is only possible to evaluate the effectiveness of procurement by analyzing the indicators that determine the inventory [10].

3. Part of the research

It is necessary to analyze the financial and procurement conditions of the major factories and enterprises of our country, such as "Erdenet Industry" SOE, "Erdenes Tavantolgoi" JSC, "Mongolrostsvetmet" JSC, "Cement and Lime" JSC, and "Baganuur" JSC.

"Erdenet Industry" SOE: In 1972, a feasibility study was approved for the ownership of the copper and molybdenumdeposit of "Erdenetyn-Ovoo", and on February 20, 1973, a historic agreement was signed between the Governments of Mongolia and the USSR regarding the use of the deposit (in its former name).

"Erdenet" plant (under its former name) was first established with 50:50 ownership in accordance with the agreement between the Governments of Mongolia and the USSR dated November 22, 1973. It began its operations on December 14, 1978 with the release of its first concentrate. From that time, the history of the Erdenet factory, the most significant development in Mongolia in the 20th century, began. The comprehensive construction of Erdenet City with complete infrastructure followed by mining has become a classic model of a large mining project.

"Erdenet" plant is a joint venture with 51:49 private ownership according to the 1991 agreement between the two countries' governments. According to the agreement of 2003, working as a limited liability company (LLC), in June 2016, the Russian corporation "Rostech" sold49 percent of its holdings. In this way, the Government of Mongolia owned 51 percent, and "Mongolian Copper Corporation"LLC owned 49 percent.

On March 21, 2019, the Government of Mongolia issued a resolution and approved the reorganization of "Erdenet Industry" into a state-owned enterprise. The long-term "Sustainable Development Policy" covering production management and management system, operational principles, and development planning was approved by Order No. A/552 dated June 13, 2019 of the General Director of Erdenet Industry. In this context, 25 goals are being proposed within the five priority directions: Technology Policy, Technical Policy, Economic and Financial Accounting Policy, Social Policy, and Environmental Policy.

Relevant laws, legal acts, and regulations carry out procurements. Procurement is being done through the Department of Investment and Procurement Policy. Under the authority of the Department are the Department of Procurement of Goods and Materials, the Department of Procurement of Works and Services, the Department of Market Research and Marketing, the Transport Logistics Center, and representative offices in Moscow and Beijing.

As of 2024, there are more than 7,000 employees (http://www.erdenetmc.mn).

"Erdenes Tavantolgoi" JSC: The project started to be implemented on August 27, 2010, and the mining work was officially started. Accordingly, "Erdenes Tavantolgoi"JSC, which is responsible for the exploitation of Tavantolgoi coal deposits, was established on December 23, 2010, according to the decision of the Parliament and the Government. The "Erdenes Tavantolgoi" project is implemented in coal mining, product processing, infrastructure and factories construction, water supply system construction, additional exploration and research of deposits, delivery of products to international markets, and stock trading in domestic and international stock markets.

Procurements are carried out following relevant laws, legal acts, and regulations. In 2023, it is planned to employ 1120 employees and implement 513 projects with a total budget of 4,070.7 billion MNT and a financing amount of 1,122.9 billion MNT. Out of this, 130 tenders with a budget of 2,738.8 billion MNT were organized and a total of 2,580.9 billion MNT contracts were signed. Total budget saving is 157.0 billion MNT.

As of 2024, there are more than 1120 employees (http://www.ett.mn).

"Mongolrostsvetmet" SOE: "Mongolrostsvetmet" SOE was founded in 1973 under

the name "Mongolrostsvetmet" as a joint Mongolian-Russian joint venture under the name of "Mongolrostsvetmet"in accordance with the agreement between the governments of Mongolia and the USSR (formerly known as the USSR) and began mining fluoride, precious metals and other minerals on the territory of Mongolia. It was established with the aim of mining enrichment, increasing mineral resources, and increasing the country's export capacity. It is now in its 50th year of operation and is Mongolia's first large foreign-invested enterprise.

The joint venture has been transformed into a limited liability company since 2007 and a state-owned enterprise since 2019. From 1973 to 2016, 51% of the Regulatory Fund of the Department of Industry was owned by Mongolia and 49% by the Russian Federation, and from 2016, it was transferred to 100% state ownership of Mongolia.

As of today, the industrial site is operating as the administration in Ulaanbaatar city, the "Bor-Ondur" mountain concentrator plant located in Bor-Ondur Sum, Khentii Province, and the "Shijir Alt" gold plant located in Zaamar Sum, Central Province. Procurements are carried out in accordance with relevant laws, legal acts, and regulations. Procurement is done through the Department of Procurement and Supply, which is under the Department of Economic and Trade Policy.

As of 2024, there are more than 1,550 employees (http://www.mongolros.mn).

"Cement and Lime" SPC: Khotli Cement and Lime Combine was first established in 1983 with the structure of a cement factory, a lime factory, a mountain extraction plant, a repair and mechanic office, and a thermal plant.

According to Resolution No. 124 of the Government of Mongolia dated March 23, 2022, "Cement and Lime" TOHK started operating as a state-owned company. According to the Government of Mongolia resolution dated July 5, 2023, "Cement and Lime" LLC is to be operated as a part of "Erdenes Mongolia" LLC.

In 2023, by Government Resolution No. 258, the form of the company was changed to a Limited Liability Company. In this way, the status of SPC was officially transferred to the status of LLC on October 31, 2023.

"Cement and Lime" LLC produces about 1 million tons per year from open-pit mines of "Khotol-1" and "Khotol-2" limestone deposits and supplies raw materials to Lime and Stone factories. A stone plant produces a semi-finished product (clinker) and supplies it to a cement plant, while a cement plant produces the final product, grade 32.5, 42.5, and 52.5 cement, and sells it to the market.

The relevant laws, legal acts, and regulations carry out the procurement process. Procurement is done through the Procurement Department, which is under the Finance and Economic Department. As of 2024, there are more than 800 employees (http://www.khutulcement.mn).

"Baganuur" JSC: It was first established in 1978 under the name "Baganuur Coal Mine" with 200,000 tons of coal capacity. It is now in its 45th year. In 1995, it became a joint-stock company, and in 2012, it became a subsidiary of "Erdenes Mongolia" LLC. 75% of the shares are owned by "Erdenes Mongolia" LLC, 21.06% by Mongolian Coal Corporation, and 3.94% by other small enterprises. It provides 60% of Mongolia's energy coal. As of April 2024, a total of 1139 employees are working. The annual capacity is 4 million tons of thermal coal. In 2024, 80 projects and tenders for a total of 148.4 billion MNT are planned.

The sales revenue of Baganur JSC increased by 14.7 percent on average in the last three years. As of 2023, it is planned to earn a total of 214.6 billion MNT, spend 224.4 billion MNT, and incur a loss of 9.8 billion MNT. However, in terms of performance, it earned 212.6 billion MNT and spent 222.1 billion MNT, with a loss of 9.5 billion MNT. The planned loss was 249.0 million MNT, and 24.1 billion MNT reduced the loss from the previous year. Baganur JSC announced 69 tenders in 2022, and 29 tenders were successful. In 2023, out of 156 tenders, 124 were successful. In 2023, purchases of MNT 635.0 million were made to support domestic production. In 2023, investments of 49.9 billion MNT were financed with their own funds.

The procurement process is carried out in accordance with the relevant laws, legal acts and regulations. Procurement is done through the Department of Trade and Supply, which reports to the Deputy Director of Finance and Investment.

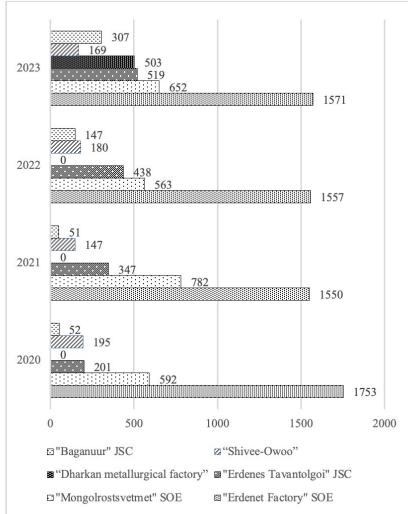
As of 2024, there are more than 1140 employees (http://www.baganuurmine.mn).

3.1. Electronic Tender for Procurement

In 2020-2023, the enterprises involved in the research published a total of 12,276 tender invitations through the public procurement system www.tender.gov.mn. This represents 12.1% of the total invitations announced by the electronic system during the above period.

Table 1: Comparative study of tender invitations of some state-owned organizations posted on the public procurement system

№	Organization Name	2020 year	2021 year	2022 year	2023 year	SUM
1.	"Erdenet Industry"	1,753	1,550	1,557	1,571	6,431
2.	"Mongolrostsvetmet"	592	782	563	652	2,589
3.	"Erdenes Tavantolgoi"	201	347	438	519	1,505
4.	"Dharkan Metallurgical Factory"	-	-	-	503	503
5.	"Shivee-Ovoo"	195	147	180	169	691
6.	"Baganuur"	52	51	147	307	557
7.	**Total**	2,793	2,877	2,885	3,721	12,276
8.	The total number of invitations to tender announced through the electronic system	16,524	21,739	30,559	32,893	101,715
9.	**Percentage of total invitations**	16.9%	13.2%	9.4%	11.3%	12.1%



Source: www.tender.gov.mn electronic system of public procurement, 2020-2023 procurement implementation report of the Ministry of Finance's portfolio managers

Figure 1: Survey of invitations to tender announced by the surveyed organizations in 2020-2023 through the electronic system of public procurement www.tender.gov.mn

"Erdenet Industry" SOE published 1,753 tender invitations in 2020, 1,550 in 2021, 1,557 in 2022, 1,571 in 2023, and 6,431 tenders in 2020-2023. The number of e-invites published in 2023 decreased by 12% compared to 2020.

"Mongolrostsvetmet" SOE has published 592 tender invitations in 2020, 782 in 2021, 563 in 2022, 652 in 2023, and 2,589 tenders in 2020-2023. The number of e-invites published in 2023 increased by 10% compared to 2020.

"Erdenes Tavantolgoi" JSC published 201 tender invitations in 2020, 347 in 2021, 438 in 2022, 519 in 2023, and 1,505 tenders in 2020-2023. The number of e-invitations published in 2023 increased by 2.6 times compared to 2020.

"Shivee-Ovoo" JSC published 195 tender invitations in 2020, 147 in 2021, 180 in 2022, 169 in 2023, and 691 tenders in 2020-2023. The number of e-invites published in 2023 decreased by 15% compared to 2020. "Baganuur" JSC published 52 tender invitations in 2020, 51 in 2021, 147 in 2022, 307 in 2023, and 557 tenders in 2020-2023. The number of e-invitations published in 2023 increased 5.9 times compared to 2020

3.2. Evaluation and analysis of the effectiveness of procurement management

In the works of foreign researchers, the following financial indicators are named that allow the evaluation of the effectiveness of the acquisition management of an enterprise [11]. It includes:

1) Return on Assets (ROA);
2) Return on Sales (ROS);
3) Coefficient of Capital Capacity (Capital Intensity);
4) Share of Working Capital in Assets;
5) Ratio of Inventory Costs to Sales Revenue;
6) Ratio of Accounts Payable to Sales Revenue.

The main indicators that determine inventory management efficiency include the following indicators. It includes:

1) Inventory Turnover Rate;
2) Inventory Turnover Period;
3) Inventory Capacity;
4) Share of Inventory Reserves in Assets.

The following parameters of selected state-owned mining enterprises and enterprises were calculated and compared. It includes:

1. Return on Assets (ROA):

$$\text{ROA} = \left(\frac{\text{TSA}}{C}\right) \times 100$$

- ROA – return on assets, %;
- TSA – net profit, MNT;
- C – total assets, MNT.

2. **Return on Sales (ROS):**

$$\text{ROS} = \left(\frac{\text{TSA}}{\text{BO}}\right) \times 100$$

- ROS – return on sales, %;
- TSA – net profit, MNT;
- BO – sales revenue, MNT.

3. **Capital Intensity Ratio:**
The lower this ratio, the more profitable it is.

$$K_1 = \frac{\text{EBH}}{\text{BO}}$$

- K_1 – capital intensity coefficient;
- EBH – non-current assets, MNT;
- BO – sales revenue, MNT.

4. **Share of Working Capital in Assets:**

$$K_2 = (EH \div HC) \cdot 100,$$

Here, K – share of working capital in assets;

- EH – working capital, MNT;
- HC– total assets, MNT.

5. **Ratio of inventory costs to sales revenue:**

$$K_3 = (T \div BO) \cdot 100,$$

Here, K3 – the ratio of inventory costs to sales revenue, %;

- T – payment to the supplier, MNT;
- BO – sales revenue, MNT.

6. **Ratio of accounts payable to sales revenue:**

$$K_4 = (NTO \div BO) \cdot 100,$$

Here, $K4$ – the ratio of accounts payable to sales revenue, %;

- NTO – debt to the publisher, MNT;
- BO – sales revenue, MNT.

7. **Inventory turnover rate:**

$$K_5 = (BBE \div BM),$$

Here, $K5$ – inventory turnover speed, times;

- BBE – cost of sold products, MNT;
- BM – average stock of inventory, MNT.

8. Inventory turnover period:

$$K_6 = 365 \div (BBE \div BM),$$

Here, $K6$ – inventory turnover period, days;

- BBE – cost of sold products, MNT;
- BM – average stock of inventory, MNT.

9. Inventory capacity:

$$K_7 = BM \div BO,$$

Here, $K7$ – inventory capacity;

- BM – average stock of inventory, MNT;
- BO – sales revenue, MNT.

10. Share of inventory in assets:

$$K_8 = (BM \div HC) \cdot 100,$$

Here, $K8$ – % share of inventory stock in assets;

- BM – stock of inventory, MNT;
- HC – total assets, MNT.

Table 2: A study of financial indicators to evaluate the effectiveness of procurement management

№	Indicator	Revenue, billion	Return on Assets (ROA)	Return on Sales (ROS)
1.	“Erdenet Industry”	1,683.2	14.2%	22.2%
2.	“Erdenes Tavantolgoi”	1,578.8	4.2%	23.9%
3.	“Mongolrostsvetmet”	98.0	23.0%	20.9%
4.	“Baganuur”	20.2	0.3%	2.3%
5.	Cement and Lime	20.0	4.2%	14.1%
6.	Average value	680.0	9.2%	16.7%
7.	Minimum value	20.0	0.3%	2.3%
8.	Maximum value	1,683.2	23.0%	23.9%

№	Indicator	K_1	K_2	K_3	K_4
1.	“Erdenet Industry”	1.52	24.9%	9.4%	3.2%
2.	“Erdenes Tavantolgoi”	7.29	90.4%	34.6%	12.0%
3.	“Mongolrostsvetmet”	0.76	89.1%	15.7%	15.1%
4.	“Baganuur”	1.32	64.2%	23.7%	37.6%
5.	Cement and Lime	2.89	48.4%	27.3%	3.7%
6.	Average value	2.76	63.4%	22.2%	14.3%
7.	Minimum value	0.76	24.9%	9.4%	3.2%
8.	Maximum value	7.29	90.4%	34.6%	37.6%

№	Indicator	K_5	K_6	K_7	K_8
1.	"Erdenet Industry"	2.87	128.95	8.5%	13.8%
2.	"Erdenes Tavantolgoi"	3.81	137.16	1.4%	11.3%
3.	"Mongolrostsvetmet"	1.46	393.7	29.3%	51.0%
4.	"Baganuur"	3.43	137.51	12.0%	21.9%
5.	Cement and Lime	3.19	114.53	7.0%	23.8%
6.	Average value	3	182.4	11.6%	24.4%
7.	Minimum value	1.5	114.5	1.4%	11.3%
8.	Maximum value	3.8	393.7	29.3%	51.0%

Source: Researcher's processing from the data source of the financial statements of the enterprises in the mining sector for 2020-2023 in the ShilenDans (Glass account).

The average return on assets (ROA) value is 9.2%, the minimum value is 0.3%, and the maximum value is 23.0%.

High-income organizations include organizations with a return on capital of more than 20%, medium-income organizations with a return on assets of 5%-20%, and low-efficiency organizations with less than 5% [12].

"Mongolrostsvetmet" LLC belongs to the high-income group, "Erdenet Industry" SOE belongs to the middle-income group, and "Erdenes Tavantolgoi" JSC, "Cement and Lime" LLC, and "Baganuur" LLC belong to the low-income group.

Return on sales (ROS) determines the income earned by the organization from the sale of goods and represents the effectiveness of the enterprise's business operations [13].

For the surveyed enterprises, the average value of return on sales is 16.7%, the minimum value is 2.3%, and the maximum value is 23.9%.

"Erdenes Tavantolgoi" JSC, "Erdenet Industry" SOE, "Mongolrostsvetmet" LLC are among those with a high return on sales, "Cement and Lime" JSC has an average return, and "Baganuur" JSC has a low return.

Capital capacity indicator K_1 is an indicator that shows how much capital is used to earn one MNT profit.

For the surveyed enterprises, the average value of capital capacity is 2.76, the minimum value is 0.76, and the maximum value is 7.29. In 2019-2022, "Mongolrostsvetmet" LLC earned 0.76 MNT, "Baganuur" LLC earned 1.32 MNT, "Erdenet Industry" LLC earned 1.52 MNT, "Cement Lime" LLC earned 2.89 MNT, "Erdenes Tavantolgoi" LLC earned 7.29 MNT by spent 1 MNT.

As mentioned earlier, an essential component of increasing the profitability of enterprises is the reduction of production costs, and this can be done by reducing production procurement costs in the context of material production, including mining enterprises.

The share of working capital in assets K_2 has an average value of 63.4%, a minimum value of 24.9%, and a maximum value of 90.4%.

A high ratio of working capital to assets is often considered a positive sign. It shows that the object of labor prevails over the means of labor in the enterprise's property.

It should be remembered that an increase in the share of working capital is a normal phenomenon of enterprise activity. The following factors influence this:

- accumulation of depreciation of non-current assets, which leads to a decrease in the value of non-current assets and a corresponding increase in the price of current assets;
- the formation of profits increases the value of working capital, capital, and reserves (losses reduce the value of these parts of the balance sheet).

The cost and share of working capital may increase with the withdrawal of loans and credits. So, the lowest share of working capital in assets is "Erdenet Industry" SOE, "Cement

and Lime" SOE and "Baganuur" SOE are in the middle, and "Mongolrostsvetmet" LLC and "Erdenes Tavantolgoi" SOE are the highest.

The ratio of inventory costs to sales revenue K_3 is 22.2% on average, with a minimum of 9.4% and a maximum of 34.6%. The organization of relations with suppliers occupies a special place in the activities of any enterprise. Timely payment for delivered products is an indisputable condition for concluding any contract or transaction. In some cases, accounts payable can be an enterprise's financing source, allowing suppliers to invest unpaid funds in their operations. However, if suppliers make late payments, additional costs may be associated with late payment of contractual obligations, the company's reputation with potential partners may be damaged, and problems may arise in the future.

The average value of the ratio of accounts payable to sales revenue k_4 for the surveyed enterprises is 14.3%, the minimum value is 3.2%, and the maximum value is 37.6%. When calculating the indicators of enterprise inventory management:

- The average value of inventory turnover K_5 is 3.0 times, the minimum value is 1.5 times, the maximum value is 3.8 times,
- The average value of inventory turnover time K_6 is 182.4 days, the minimum value is 114.5 days, and the maximum value is 393.7 days,
- The average value of inventory capacity K_7 is 24.4%, the minimum value is 11.3%, and the maximum value is 51.0%,
- The average value of the share of inventory resources K_8 in assets is 11.6%, the minimum value is 1.4%, and the maximum value is 29.3%.

As can be seen from the above indicators, inventory management is efficiently implemented by "Erdenes Tavantolgoi" JSC and "Erdenet Industry" SOE among the enterprises involved in the research. In 2021-2022, "Mongolrostsvetmet" LLC doubled exploration costs compared to the previous year and increased capital investment by an average of 42 times (including open-pit mining machines and mechanisms (excavators, dump trucks, and bulldozers).Research shows that large increases in inventory capacity reduce return on assets.

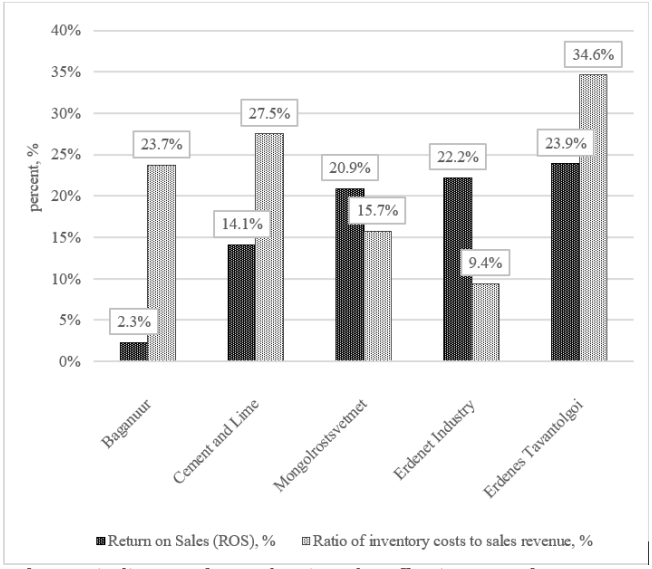
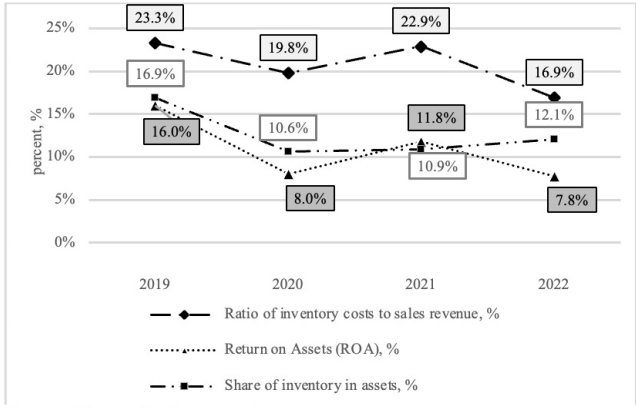


Figure 1: Correlation of some indicators for evaluating the effectiveness of procurement management in the surveyed organizations (by company)

According to the research results, the return on capital will be the highest in 2019 and the lowest in 2022 at 7.8%. The best asset returns were in 2019 (the year before the global

Covid-19 pandemic). The worst year for asset returns was 2022, driven by the global Covid-19 pandemic, rising commodity and inventory prices, and currency appreciation.



Source: Researcher's processing.

Figure 3: Correlations of some indicators for evaluating the effectiveness of procurement management in the surveyed organizations (by year)

In the years covered by the study, the share of inventory in reserve assets varied from 10.6 to 16.9%. In general, increasing inventory capacity is not beneficial.

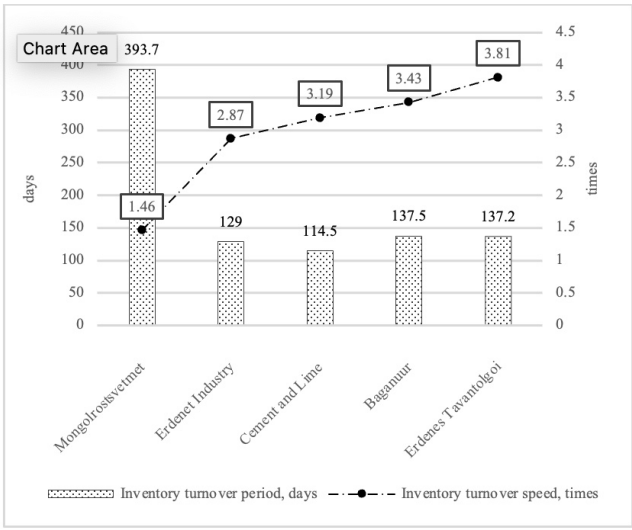


Figure 4: Correlation of some indicators for evaluating the effectiveness of procurement management in the surveyed organizations (by company)

The study showed that the efficiency of enterprises depends on internal (effectiveness of purchasing management) and external environment (changes in prices of raw materials and finished products).

The study's results clearly show the importance of regularly evaluating the effectiveness of the organization's procurement. Currently, there is no unified method for evaluating the results of mining enterprises' procurement. In such a situation, it becomes essential to develop and implement a methodology for evaluating the procurement activities of mining enterprises.

Return on assets is the most critical indicator of the organization's performance. In order to make optimal decisions to improve operational efficiency, these indicators should be considered not only statically but also over time. Changes in these indicators show the results of the

organization's internal management. One of the main ways to increase profitability is to increase profits by reducing the cost of purchasing the necessary resources for the enterprise. On the other hand, inventory costs depend largely on the efficiency of inventory management, which affects the amount of assets. Regular monitoring of the above indicators and comparison with industry averages is an integral part of effective management.

3.3. Correlation-Regression Analysis

Correlation-regression analysis can be used to determine the influence and change patterns between factors. With its help, a mathematical model can be created as a regression equation.

The primary purpose of correlation analysis is to determine the strength and form of correlation between the studied variables.

Regression analysis is used to determine the form of relationship between variables or to detect their relationship, to evaluate this relationship, and to evaluate unknown values of related variables. Correlation-regression analysis was performed using Stata 9.0 software [14], [15].

Table 3: Survey of financial indicators to evaluate the effectiveness of procurement management in the surveyed organizations

№	Indicator	Year	Return on assets (ROA) Y_1	Return on Sales (ROS) Y_2
1.	"Erdenet Industry"	2019	22.3%	25.3%
2.		2020	4.8%	12.1%
3.		2021	15.6%	29.1%
4.		2022	14.2%	22.4%
5.	"Erdenes Tavan Tolgoi"	2019	7.7%	38.9%
6.		2020	1.1%	9.6%
7.		2021	0.7%	9.8%
8.		2022	7.5%	37.3%
9.	"Mongolros-tsvetmet"	2019	34.1%	24.9%
10.		2020	27.1%	23.0%
11.		2021	30.2%	34.1%
12.		2022	0.4%	1.5%
13.	"Cement and Lime" "Baganuur"	2022	4.2%	14.1%
14.		2019	0.0%	0.1%
15.		2020	-0.8%	-1.4%
16.		2021	0.6%	1.0%
17.		2022	-0.1%	-0.1%

Table 4: Survey of financial indicators to evaluate the effectiveness of procurement management in the surveyed organizations

№	Indicator	Year	K_1, coeff	K_2, %	K_3, %	K_4, %
1.	"Erdenet Industry"	2019	0.76	32.7%	10.5%	2.5%
2.		2020	2.26	28.6%	8.9%	3.6%
3.		2021	1.66	20.6%	7.1%	3.7%
4.		2022	1.40	17.6%	10.9%	3.1%
5.	"Erdenes Tavan Tolgoi"	2019	4.64	39.1%	30.9%	6.9%
6.		2020	8.36	77.4%	28.6%	23.9%
7.		2021	11.86	172.9%	54.6%	12.7%
8.		2022	4.28	72.3%	24.3%	4.7%
9.	"Mongolros-tsvetmet"	2019	0.32	41.4%	20.7%	6.5%
10.		2020	0.43	41.5%	14.8%	3.1%
11.		2021	0.42	70.8%	12.1%	2.1%
12.		2022	1.87	202.6%	15.0%	48.8%
13.	"Cement and Lime" "Baganuur"	2022	2.89	48.4%	27.5%	3.7%
14.		2019	0.95	39.3%	30.9%	37.1%
15.		2020	1.42	33.6%	26.7%	38.5%
16.		2021	1.39	35.5%	17.8%	27.3%
17.		2012	1.26	35.7%	249%	36.5%

Table 5: Survey of financial indicators to evaluate the effectiveness of procurement management in the surveyed organizations

№	Indicator	Year	K_5, удаа	K_6, хоног	K_7, %	K_8, %
1.	"Erdenet Industry"	2019	3.20	114.10	14.8%	13.0%
2.		2020	3.17	115.27	14.0%	5.5%
3.		2021	2.36	154.34	13.4%	7.2%
4.		2022	2.76	132.09	13.0%	8.2%
5.	"Erdenes Tavan Tolgoi"	2019	6.59	55.38	4.0%	0.8%
6.		2020	5.19	70.37	8.4%	0.9%
7.		2021	1.66	220.12	23.4%	1.7%
8.		2022	1.80	202.77	11.3%	2.3%
9.	"Mongolros-tsvetmet"	2019	1.64	221.97	27.5%	37.6%
10.		2020	2.40	152.23	19.9%	23.5%
11.		2021	1.40	260.96	25.1%	22.3%
12.		2022	0.39	939.66	131.4%	33.8%
13.	"Cement and Lime" "Baganuur"	2022	3.19	114.53	23.8%	7.0%
14.		2019	4.32	84.48	22.0%	16.3%
15.		2020	4.15	87.88	22.0%	12.5%
16.		2021	3.97	91.92	21.6%	12.5%
17.		2022	4.14	88.09	21.9%	13.5%

Correlation analysis shows:

Table 6: Correlation coefficient

Indicator	***ROA***	***ROS***	K_1	K_2	K_3
ROA	1.0000				
ROS	0.6670	1.0000			
K_1	-0.4340	-0.0380	1.0000		
K_2	-0.2709	-0.2204	0.5296	1.0000	
K_3	-0.4706	-0.2564	0.7621	0.4283	1.0000

Table 7: Correlation coefficient

Indicator	***ROA***	***ROS***	K_1	K_2	K_3
K_4	-0.6466	-0.8155	-0.0205	0.3688	0.2433
K_5	-0.3869	-0.1173	0.1222	-0.5057	0.2269
K_6	-0.0265	-0.1381	-0.0542	0.7804	-0.1426
K_7	-0.1597	-0.3639	-0.1312	0.7269	-0.1080
K_8	0.4937	-0.1288	-0.5942	0.1908	-0.3351

Table 8: Correlation coefficient

Indicator	K_4	K_5	K_6	K_7	K_8
K_4	1.0000				
K_5	0.1327	1.0000			
K_6	0.3845	-0.6652	1.0000		
K_7	0.5652	-0.5416	0.9606	1.0000	
K_8	0.2559	0.5309	0.5687	0.6123	1.0000

- the following combinations are directly strongly and very strongly related:
  $ROA - ROS, K_1 - K_2, K_1 - _3, K_2 - K_7, K_4 - K_7, K_5 - K_8, K_6 - K_7, K_6 - K_8, K_7 - K_8$

- the following combinations are inversely strongly and very strongly related:
  $ROA - K_4, ROSK_4, K_1 - K_8, K_2 - K_5, K_5 - K_6, K_5 - K_7$.

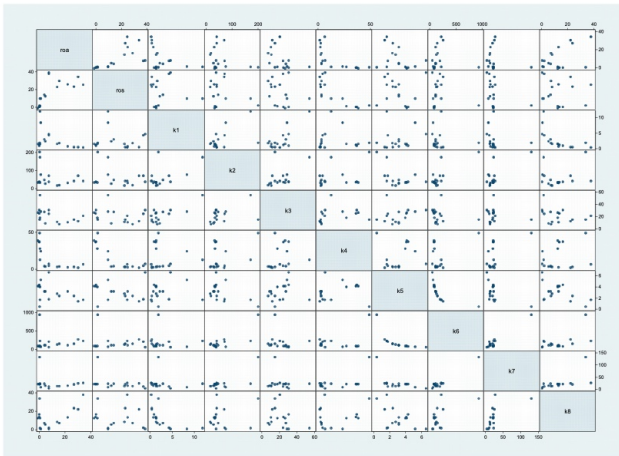


Figure 5. Graphic matrix

3.4. Regression analysis

Let us develop a regression model of the surveyed enterprises' financial and procurement management factors. Select Y1-return on assets (ROA) and Y2-return on sales (ROS) as function indicators.
Regression equation:

$$Y_1\,(ROA) = 5.04 - 0.62x_1 + 0.13x_2 - 0.25x_3 - 0.38x_4 + 1.59x_5 + 0.04x_6 - 0.58x_7 + 1.01x_8 (R2 = 0.97) \quad (3.1)$$

$$Y_2\,(ROS) = 0.44 - 2.86x_1 - 0.0002x_2 + 0.49x_3 - 0.54x_4 + 5.14x_5 + 0.22x_6 - 1.44x_7 - 0.003x_8 (R2 = 0.97) \quad (3.2)$$

Here, Y_1 – return on assets (ROA), percent;
Y_2 – return on sales (ROS), percent;
x_1 – capital intensity coefficient;
x_2 – share of working capital in assets;
x_3 – the ratio of inventory costs to sales revenue, %; x_4 – the ratio of accounts payable to sales revenue;
x_5 – inventory turnover speed, times;
x_6 – inventory turnover period, days;
x_7 – inventory capacity;
x_8 – share of inventory stock in assets, %.

Source	SS	df	MS	Number of obs =	17
				F(8, 8) =	26.87
Model	2140.60272	8	267.57534	Prob > F =	0.0001
Residual	79.6662034	8	9.95827543	R-squared =	0.9641
				Adj R-squared =	0.9282
Total	2220.26893	16	138.766808	Root MSE =	3.1557

roa	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
k1	-.6205463	.9805573	-0.63	0.544	-2.881716	1.640623
k2	.1265299	.0931901	1.36	0.212	-.0883668	.3414266
k3	-.2487819	.1662134	-1.50	0.173	-.6320706	.1345068
k4	-.3818778	.0953774	-4.00	0.004	-.6018183	-.1619372
k5	1.593593	.9992656	1.59	0.149	-.7107175	3.897904
k6	.0373296	.0279061	1.34	0.218	-.0270218	.1016811
k7	-.582985	.184376	-3.16	0.013	-1.008157	-.1578132
k8	1.009756	.1445238	6.99	0.000	.6764836	1.343028
_cons	5.042252	4.554793	1.11	0.300	-5.461119	15.54562

Figure 2: Regression Y_1 (ROA)

Source	SS	df	MS	Number of obs =	17
				F(8, 8) =	32.61
Model	2987.02312	8	373.37789	Prob > F =	0.0000
Residual	91.5988258	8	11.4498532	R-squared =	0.9702
				Adj R-squared =	0.9405
Total	3078.62195	16	192.413872	Root MSE =	3.3838

ros	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
k1	-2.855167	1.051431	-2.72	0.026	-5.279772	-.4305621
k2	-.0001717	.0999258	-0.00	0.999	-.230601	.2302575
k3	.4851825	.1782271	2.72	0.026	.07419	.896175
k4	-.539302	.1022712	-5.27	0.001	-.7751397	-.3034642
k5	5.144944	1.071492	4.80	0.001	2.67408	7.615809
k6	.2267268	.0299231	7.58	0.000	.1577241	.2957296
k7	-1.441709	.1977025	-7.29	0.000	-1.897612	-.985806
k8	-.0032914	.1549698	-0.02	0.984	-.3606525	.3540696
_cons	.4413434	4.80401	0.09	0.930	-10.8212	11.70389

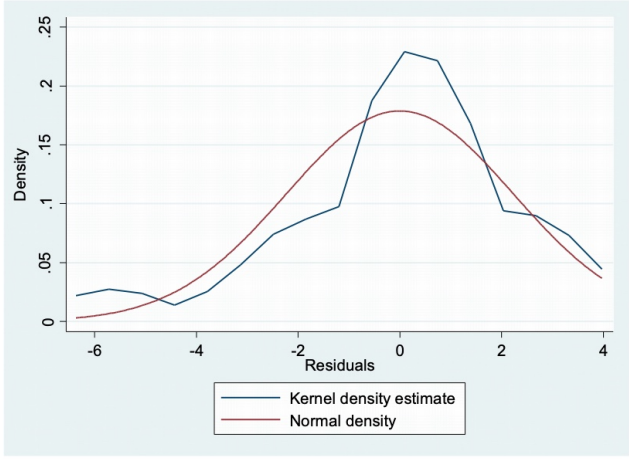
Figure 7. Regression $Y_2(ROS)$

It can be seen from the regression equation (1):

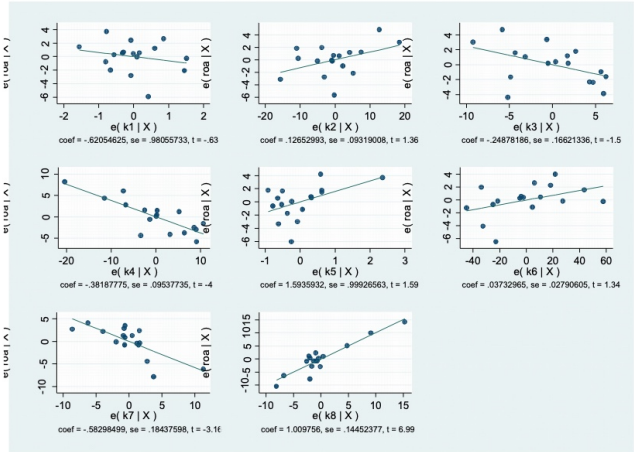
- Return on assets decreases by 0.62 point when x1 - the capital intensity coefficient increases by one unit, increases by 0.13 point when x2 - the share of working capital in assets increases by one unit, decreases by 0.25 point when x3 - the ratio of inventory costs to sales revenue increases by one unit, decreases by 0.38 point when x4 - the ratio of accounts payable to sales revenue increases by one unit, increases by 1.59 point when x5 - the inventory turnover speed increases by one unit, increases by 0.04 point when

x6 - the inventory turnover period increases by one unit, decreases by 0.58 point when x7 - the inventory capacity increases by one unit, increases by 1.01 point when x8 - the share of inventory stock in assets increases by one unit.

- The coefficient of determination of the regression equation is 0.96, or 96% of reality is explained.
- x_2 - the share of working capital in assets, x_5 - the inventory turnover speed, x_6 - the inventory turnover period and x_8 - the share of inventory stock in assets have a direct positive effect on return on assets.
- However, x_1 - the capital intensity coefficient, x_3 - the ratio of inventory costs to sales revenue, x_4 - the ratio of accounts payable to sales revenue and x_7 – the inventory capacity have a negative impact on return on assets.
- The kernel density function distribution is shown below



- The Shapiro-Wilk test result is 0. 21044, which means that the significance level is more significant than 0.05, thus confirming the hypothesis of normal distribution
- According to the Breusch-Pagan test, the model is not heteroskedastic (0. 9346>0.05)



- The criteria for checking whether the model is correctly defined is that $P > |t| is 0.871$ or the significance level is more significant than 0.05, so the selected variables are optimal.

- According to the Ramsey reset criterion, the F statistic is 1.49, and the probability of 0. 3236 is greater than the significance level of 0.05, so the model is optimal.

According to the regression equation (2):

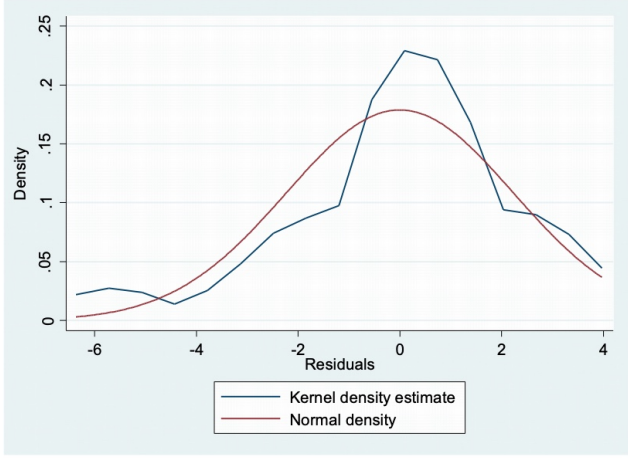
- Return on sales decreases by 2.86 points when x_1 - the capital intensity coefficient increases by one unit, decreases by 0.0002 point when x_2 - the share of working capital in assets increases by one unit, increases by 0.49 point when x_3 - the ratio of inventory costs to sales revenue increases by one unit, decreases by 0.54 point when x_4 - the ratio of accounts payable to sales revenue increases by one unit, increases by 5.14 point when x_5 - the inventory turnover speed increases by one unit, increases by 0.22 point when x_6 - the inventory turnover period increases by one unit, decreases by 1.44 point when x_7 - the inventory capacity increases by one unit, decreases by 0.003 point when x_8 - the share of inventory stock in assets increases by one unit.

- The coefficient of determination of the regression equation is 0.97. It follows that 97% of sales returns can be explained by equation (2), and the remaining 3% is the influence of other factors.

- x_3 - the ratio of inventory costs to sales revenue, x_5 - inventory turnover speed and x6 - inventory turnover period have a direct positive effect on return on sales.

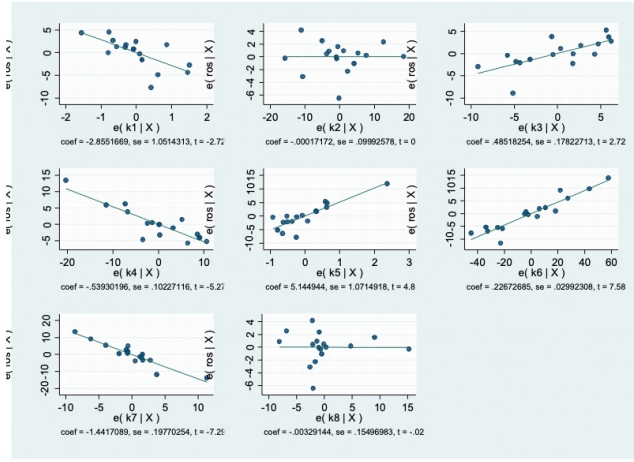
- However, x_1 - the capital intensity coefficient, x_2 - the share of working capital in assets, x_4 - the ratio of accounts payable to sales revenue, x_7 – the inventory capacity, and x_8 – the share of inventory stock in assets have a negative impact on return on assets.

- The kernel density function distribution is shown below.



- The Shapiro-Wilk test result is 0. 2104, which means that the significance level is greater than 0.05, thus confirming the hypothesis of normal distribution.

- According to the Breusch-Pagan test, the model is not heteroskedastic (0. 6093>0.05).



3.5. Mathematical model for optimization of purchasing sustainability

Indicators affecting return on assets and return on sales are the most important indicators of company performance. In order to make optimal decisions to improve the efficiency of the company's operations, it is necessary to consider these indicators not only in one specific period but also over time. Changes in these indicators show the results of the organization's internal management. Planning the company's procurement budget to ensure the organization's financial stability is one of the main ways to increase its profitability. Regular monitoring of procurement performance is a part of effective management.

Let us develop optimal management decision-making models with purchasing indicators to ensure the stability of the financial operations of the researched organizations.

1st stage. In the first step, the boundary condition variables of the objective function are selected. From the regression equations (1), (2), let us select the variable whose P probability is less than 0.05. Because if the P probability is more significant than 0.05, the explanatory variable has almost no effect on the explanatory variable (Kurzaeva L.V., 2016). Then, the choice of function variables is shown in Table .

Table 9: Selection of optimization model variables

№	Indicator	For the regression equation (1)	
		Value of probability P (ROA)	Choice
1.	x_1 – capital intensity coefficient	0.544	
2.	x_2 – share of working capital in assets	0.212	
3.	x_3 – the ratio of inventory costs to sales revenue	0.173	
4.	x_4 – the ratio of accounts payable to sales revenue	0.004	✓
5.	x_5 – inventory turnover speed, times	0.149	
6.	x_6 – inventory turnover period, days	0.218	
7.	x_7 – inventory capacity	0.013	✓
8.	x_8 – share of inventory stock in assets	0.000	✓

The selected variables were selected as influencing factors or variables of the optimization model. It includes: x_1 – capital intensity coefficient,

Table 10: Selection of optimization model variables

		For the regression equation (2)	
№	Indicator	Value of probability P (ROS)	Choice
1.	x_1 – capital intensity coefficient	0.026	✓
2.	x_2 – share of working capital in assets	0.999	
3.	x_3 – the ratio of inventory costs to sales revenue	0.026	✓
4.	x_4 – the ratio of accounts payable to sales revenue	0.001	✓
5.	x_5 – inventory turnover speed, times	0.001	✓
6.	x_6 – inventory turnover period, days	0.000	same as the K_5, so it is excluded
7.	x_7 – inventory capacity	0.000	✓
8.	x_8 – share of inventory stock in assets	0.984	

x_2 – the ratio of inventory costs to sales revenue,
x_3 – the ratio of accounts payable to sales revenue,
x_4 – inventory turnover speed, times,
x_5 – inventory capacity,
x_6 – share of inventory stock in assets.

$2^n d$ **stage** Determine the criteria for the optimization model. For this, the selected variables represent the objective function and its maximum or minimum value is found.

$3^n d$ **stage** Constraint conditions or a system of policy constraints are established to establish the relationship between factors [16].

A necessary condition for determining the principle of rationality of planning and management is flexibility, or conditions of production and economic alternatives.

The essence of the model for optimizing the sustainability of procurement is to choose the planning and management decisions that best consider the external conditions, using the internal possibilities of the production activity of enterprises. Therefore, the practical implementation of the principle of optimality of planning and management decisions means finding the solution of a function of the following form:

$$\max f(\vec{X}), \vec{X} \in D(3) \tag{3.3}$$

Here, $f(\vec{X})$ is the objective function of optimization:

$$f(\vec{X}) = f(x_1, x_2, ..., x_n)(4) \tag{3.4}$$

The conditions of limitation are:

$$\begin{cases} \varphi_1(x_1, x_2, \ldots, x_n) \le b_1, \\ \varphi_2(x_1, x_2, \ldots, x_n) \le b_2, \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \varphi_m(x_1, x_2, \ldots, x_n) \le b_m, \\ x_j \ge 0, \quad j = 1, 2, \ldots, n \end{cases} \tag{3.5}$$

Stone-Geary customer satisfaction, which is an example of a neoclassical utility function, is represented by the following function [17] [18] [19]:

$$U(x) = \prod_{j=1}^{l} (x_j - a_j)^{\sigma j} (6) \tag{3.6}$$

A particular case of Stone-Geary customer satisfaction is the Cobb-Douglas production function [20]:

$$U(x) = \prod_{j=1}^{l} x_j^{\sigma j} (7) \tag{3.7}$$

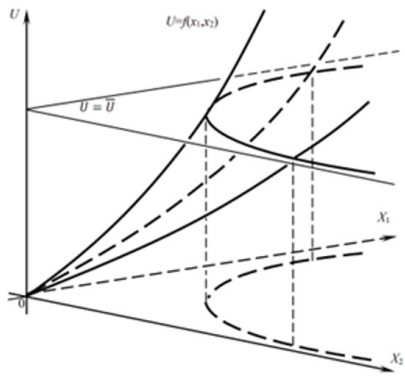


Figure 8: Neoclassical utility function

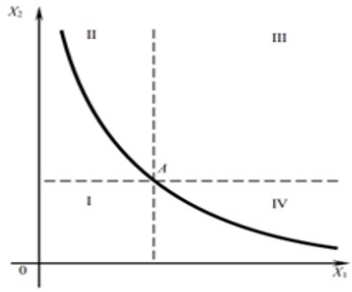


Figure 9: Indifference curve

Then, according to the Stone-Geary satisfaction function, the sustainability objective function is defined as follows:

$$Z = \sum_{i=1}^{n} (x_i - c_i)^2 \to \max \square (8) \tag{3.8}$$

$$a_i < c_i < b_i x_i \geq 0, i = 1, ..., n a_i \leq x_i \leq b_i, i = 1, ..., n \tag{3.9}$$

Here, $x_i \geq 0, i = 1, ..., n$ – research factors,

c_i – weighted average value of factor number i,

a_i – minimum value of factor number i,

b_i – maximum value of factor number i.

In our case, the influencing factors or variables are:
x_1 – capital intensity coefficient,
x_2 – the ratio of inventory costs to sales revenue,
x_3 – the ratio of accounts payable to sales revenue,
x_4 – inventory turnover speed, times,
x_5 –inventory capacity,
x_6 – share of inventory stock in assets.

Table 11: Value of indicators to evaluate the effectiveness of procurement management

№	Indicator	x_1		x_2, %	x_3, %
		koef	%	%	%
1.	"Erdenet Factory"	2.87	75.33	8.5%	13.8%
2.	"Erdenes Tavantolgoi"	3.81	100.00	1.4%	11.3%
3.	"Mongolrostsvetmet"	1.46	38.32	29.3%	51.0%
4.	"Baganuur"	3.43	90.03	12.0%	21.9%
5.	Cement and Lime	3.19	83.73	7.0%	23.8%
6.	Average value	2.95	77.43	11.6%	24.4%
7.	Minimum value	1.46	38.32	1.4%	11.3%
8.	Maximum value	3.81	100.00	29.3%	51.0%

Table 12: Value of indicators to evaluate the effectiveness of procurement management

№	Indicator	x_4		x_5	x_6
		koef	%	%	%
1.	"Erdenet Factory"	2.87	75.33	8.5%	13.8%
2.	"Erdenes Tavantolgoi"	3.81	100.00	1.4%	11.3%
3.	"Mongolrostsvetmet"	1.46	38.32	29.3%	51.0%
4.	"Baganuur"	3.43	90.03	12.0%	21.9%
5.	Cement and Lime	3.19	83.73	7.0%	23.8%
6.	Average value	2.95	77.43	11.6%	24.4%
7.	Minimum value	1.46	38.32	1.4%	11.3%
8.	Maximum value	3.81	100.00	29.3%	51.0%

Then the mathematical model of the optimization will take the following form:
1. An optimization model to maximize return on assets:

$$Z = (x_3 - 0.14)^2 + (x_5 - 0.12)^2 + (x_6 - 0.24)^2 \to max \tag{3.10}$$

The limiting conditions are:

$$\begin{aligned} 0.03 \le x_3 \le 0.38, \\ 0.01 \le x_5 \le 0.29, \\ 0.11 \le x_6 \le 0.51. \end{aligned} \tag{3.11}$$

2. An optimization model for maximizing return on sales:

$$Z = (x_1 - 0.38)^2 + (x_2 - 0.22)^2 + (x_3 - 0.14)^2 + (x_4 - 0.77)^2 + (x_5 - 0.12)^2 \to \max \tag{3.12}$$

The limiting conditions are:

$$\begin{aligned} &0.10 \le x_1 \le 1.00, \\ &0.09 \le x_2 \le 0.35, \\ &0.03 \le x_3 \le 0.38, \\ &0.38 \le x_4 \le 1.00, \\ &0.01 \le x_5 \le 0.29. \end{aligned} \tag{3.13}$$

Example of thinking: To simplify the process of finding the solution to the objective function, the following method can be used. For example, the interval length for each indicator or variable can be determined, and all data can be normalized so that the length of each interval is equal to one [21].

To find the solution of the objective function, the variables are normalized, and the expression in the function bracket (13) can be replaced by:

$$x_i - c_i \Rightarrow \frac{a_i - c_i}{b_i - a_i} \tag{3.14}$$

Table 13: An example of finding a solution of an optimization model that maximizes the return on assets

				Data normalization			
Indicator	$x_{min}\ (a_i)$	$x_{max}\ (b_i)$	$\bar{x}\ (c_i)$	$z_i = a_i - c_i$	$v_i = b_i - a_i$	$\frac{z_i}{v_i}$	$\left(\frac{z_i}{v_i}\right)^2$
x_3	0.03	0.38	0.14	0.11	0.35	0.31	0.10
x_5	0.01	0.29	0.12	0.11	0.28	0.39	0.15
x_6	0.11	0.51	0.24	0.13	0.40	0.33	0.11
Total							0.12

$$\begin{cases} Z_3^* = 0.11 \\ Z_5^* = 0.11 \\ Z_6^* = 0.13 \end{cases}$$

$$\text{then} \quad Z_{\max} = 0.12$$

Table 14: An example of finding a solution of an optimization model that maximizes the return on sales

				Data normalization			
Indicator	$x_{min}\ (a_i)$	$x_{max}\ (b_i)$	$\bar{x}\ (c_i)$	$z_i = a_i - c_i$	$v_i = b_i - a_i$	$\frac{z_i}{v_i}$	$\left(\frac{z_i}{v_i}\right)^2$
x_1	0.10	1.00	0.38	0.28	0.90	0.31	0.10
x_2	0.09	0.35	0.22	0.13	0.26	0.50	0.25
x_3	0.03	0.38	0.14	0.11	0.35	0.31	0.10
x_4	0.38	1.00	0.77	0.39	0.62	0.63	0.40
x_5	0.01	0.29	0.12	0.11	0.28	0.39	0.15
Total							0.20

$$\begin{cases} Z_1^* = 0.28 \\ Z_2^* = 0.13 \\ Z_3^* = 0.11 \\ Z_4^* = 0.39 \\ Z_5^* = 0.11 \end{cases}$$

$$\text{then} \quad Z_{\max} = 0.20$$

The thought can be used for easy and quick orientation when needed, but it should be noted that this thought solution is only one case.

Solution: The problem's solution was found using the Matlab program. It includes:

1. The solution of the optimization model for the maximum return on assets:

$$x_3 = 0.38, \quad x_5 = 0.29, \quad x_6 = 0.51$$

$$Z_{max} = 0.1594 \tag{3.15}$$

2. The solution of the optimization model for the maximum return on sales:

$$x_1 = 1.00,\ x_2 = 0.35,\ x_3 = 0.38,\ x_4 = 0.38,\ x_5 = 0.29$$

$$Z_{max} = 0.6399 \tag{3.16}$$

4. Results

1. Factors that have the most significant impact on return on assets are: firstly x_6 (share of inventory stock in assets), secondly x_3 (the ratio of accounts payable to sales revenue), and third x_5 (inventory capacity) (the variable with the lowest value in the mathematical model will have the most significant effect).

2. Return on assets is highest with the ratio of accounts payable to sales revenue at 38%, inventory capacity at 29%, and share of inventory stock in assets at 51%.

3. Factors that have the most significant impact on return on sales are: firstly x_1 (capital intensity coefficient), then x_3, x_4, x_2, and x_5.

4. Return on sales is highest with the inventory turnover speed at 1.46, capital intensity coefficient at 7.29, inventory cost ratio at 35%, accounts payable ratio at 38%, and inventory capacity at 29%.

The optimization model developed based on the practical activities of mining enterprises will provide an opportunity to ensure the stability of mining enterprises through the organization of purchasing activities.

5. Conclusion

Within the framework of this research, the following tasks were completed:

1. When comparing and analyzing the procurement data of the major factories and enterprises of our country, such as "Erdenet Industry" SOE, "Erdenes Tavantolgoi" SOE, "Mongolrostsvetmet" SOE, "Cement and Lime" SOE, and "Baganuur" SOE:

   - The number of employees is between 800 and 1550. However, the largest number of 7,000 employees work in "Erdenet Industry" SOE.
   - Procurement is organized in accordance with relevant laws, legal acts and regulations.

- Organizations publish 300 to 1500 yearly tender invitations through the public procurement system www.tender.gov.mn.
- 20–280 complaints were filed by the bidders per year.
- Total assets are between 230 billion MNT and 15.1 trillion MNT.
- Annual sales revenue is approximately between 83 billion MNT and 2.7 trillion MNT.
- Net profit for the reporting period is between 11 billion MNT and 622 billion MNT. "Baganuur" JSC had a loss of approximately 8.5 billion MNT in one year.
- An average of 23 billion MNT to 682 billion MNT is spent annually to purchase inventory.
- The amount of working capital is between 56 billion MNT and 1.7 trillion MNT.
- Non-current assets are between 101 billion MNT and 4.2 trillion MNT.

2. When evaluating and analyzing the effectiveness of procurement management of the organizations involved in the study:

   - The average value of return on assets (ROA) is 9.2%, with a minimum of 0.3% and a maximum of 23%. High-income: "Mongolrostsvetmet" LLC; middle-income: "Erdenet Industry" SOE; low-income: "Erdenes Tavantolgoi" JSC, "Cement and Lime" SOE, and "Baganuur" SOE.
   - The average return on sales (ROS) is 16.7%, with a minimum of 2.3% and a maximum of 23.9%. Organizations with high ROS include "Erdenes Tavantolgoi" JSC, "Erdenet Industry" SOE, and "Mongolrostsvetmet" LLC. "Cement and Lime" JSC had an average return, while "Baganuur" JSC had a low return.
   - The average value of the capital capacity indicator (K_1) is 2.76, ranging from 0.76 to 7.29. In 2019–2022: "Mongolrostsvetmet" LLC spent 0.76 MNT, "Baganuur" SOE spent 1.32 MNT, "Erdenet Industry" SOE spent 1.52 MNT, "Cement and Lime" SOE spent 2.89 MNT,"Erdenes Tavantolgoi" SOE spent 7.29 MNT to earn 1 MNT in revenue.
   - The share of working capital in assets (K_2) has an average of 63.4%, a minimum of 24.9%, and a maximum of 90.4%. The lowest share was found in "Erdenet Industry" SOE. "Cement and Lime" SOE and "Baganuur" SOE were in the middle range, while "Mongolrostsvetmet" LLC and "Erdenes Tavantolgoi" SOE had the highest levels.
   - Research shows that large increases in inventory capacity reduce return on assets.
   - According to the research results, return on capital was highest in 2019 and lowest in 2022 at 7.8%. The best returns on assets occurred in 2019 (pre-COVID-19). The worst returns in 2022 were driven by COVID-19 impacts, rising input costs, and currency fluctuations.
   - The study highlights the importance of regularly evaluating procurement effectiveness. Ongoing monitoring of performance indicators and comparison to industry benchmarks is essential for effective management.

3. A mathematical model for optimizing the stability of mining organizations was developed based on the practical activities of the studied entities. Correlation-regression analysis yielded the following were obtained:

   - The optimization model developed based on the practical activities of mining enterprises will provide an opportunity to ensure the stability of mining enterprises through the organization of purchasing activities.

- Factors that have the greatest impact on return on assets are firstly x_6 (share of inventory stock in assets), secondly x_3 (the ratio of accounts payable to sales revenue), and third x_5(inventory capacity) (the variable with the lowest value in the mathematical model will have the greatest effect). (*In the model, variables with the lowest values have the greatest impact.*)
- Factors that have the most significant impact on return on sales are firstly x_1 (capital intensity coefficient), then x_3 (the ratio of accounts payable to sales revenue), then x_4 (inventory turnover speed), then x_2 (the ratio of inventory costs to sales revenue) and x_5 (inventory capacity) (the variable with the lowest value in the mathematical model will have the greatest effect).

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